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environmental research associates

A PROPOSAL TO CONDUCT A SPRING AND FALL FISH RESOURCE SURVEY OF STREAMS CROSSED BY THE NORTH CANOL ROAD

Prepared for

THE DEPARTMENT OF INDIAN AND NORTHERN AFFAIRS
Ottawa, Ontario

April 1982

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13 April 1982

Contract Services Division
Technical Services and Contracts Branch
Department of Indian and Northern Affairs
Room 1108
Les Terrasses de la Chaudière North Tower
10 Wellington Street
HULL, Quebec

Dear Sir:

Re: Bid on Contract No. 82-004; Fish Resource Survey-
North Canol Road

I am pleased to submit three (3) copies of our proposal entitled

"A Proposal to Conduct a Spring and Fall Fish Resource Survey of Streams Crossed by the North Canol Road".

Should anyone reviewing this proposal require additional information or clarification of any aspect of the proposal, please contact me in our Edmonton office.

Sincerely yours

John Kristensen

John Kristensen
Regional Director

JK/dw
Encl.

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A PROPOSAL TO CONDUCT A SPRING AND FALL FISH RESOURCE SURVEY OF STREAMS CROSSED BY THE NORTH CANOL ROAD

by

LGL LIMITED
environmental research associates
Edmonton, Alberta

Prepared for

THE DEPARTMENT OF INDIAN AND NORTHERN AFFAIRS
Ottawa, Ontario

April 1982

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Dave Peirson

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INTRODUCTION AND BACKGROUND

The Northern Roads and Airstrips Directorate, Department of Indian and Northern Affairs Canada (DINA) is planning to improve access to the Macmillan Pass region, Yukon Territory. Improved access, by way of the North Canol Road, is necessary, in part, to permit development of the mineral resources of the Macmillan Pass area.

As part of their initial environmental evaluation of the impacts of upgrading the North Canol Road, DINA co-funded a preliminary fisheries survey which was conducted in the summer of 1981 by Davies and Shepard (1981). Primary objectives of their survey were "to determine fish species composition and distribution; to examine stream utilization by various life stages of fish for spawning, rearing or migration; to evaluate existing road crossing structures in terms of their effect on fish movement and stream habitat; and to identify areas where additional studies may be required to complete a timetable for instream construction". Results of the preliminary survey are summarized below.

Thirty-seven road crossings were examined from the ground and 15 watershed systems between Caribou Creek and the Yukon/NWT border were surveyed from a helicopter. The following fish species were captured: chinook salmon (*Oncorhynchus tshawytscha*), Arctic grayling (*Thymallus arcticus*), northern pike (*Esox lucius*), burbot (*Lota lota*) and slimy sculpin (*Cottus cognatus*). Of these, the two species of primary significance were chinook salmon, an important commercial and sport species, and Arctic grayling, a popular sport species.

Juvnile chinook salmon were captured in streams at six of the 37 road crossings (Table 1). The furthest upstream site at which chinook salmon were captured was Boulder Creek. In addition, the authors speculated that chinook salmon may be found rearing in most of the Ross and South Macmillan river tributaries that cross the North Canol Road.

Arctic grayling were captured in 20 of the streams sampled and were suspected of inhabiting one additional stream (Table 1). The furthest upstream site at which this species was captured by Davies and Shepard (1981) was Dewhurst Creek. Fisheries biologists working for Pan Ocean Oil Ltd. in 1981 captured Arctic grayling in streams a short distance

Table 1. Known Fisheries Information for Creeks along the North Canol Road.*

Stream	km from town of Ross River	Chinook Salmon**	Arctic Grayling
Tenas Creek	11	present	present
Deep Creek	29	likely	suspected
Marjorie Creek	36	likely	present
Flat Creek	54	likely	present
180 Mile Creek	68	likely	present
Tay Creek	71	likely	present
Blue Creek	75	present	present
Flood Creek	78	likely	present
Caribou Creek	95	likely	present
Pup Creek	100	present	present
Twin Creek #1	114	present	present
Twin Creek #2	114.5	likely	present
Riddell Creek	125	present	present
Moose Creek	147	likely	present
Boulder Creek	158	present	present
Wagon Creek	181	probably nil	present
South Macmillan River #1	183	probably nil	present
Unnamed Creek	188	probably nil	present
Jeff Creek	192	probably nil	present
Hess Creek	196	probably nil	present
Dewhurst Creek	199	probably nil	present

*Information obtained from Davies and Shepard (1981).

**Although chinook salmon captured by Davies and Shepard (1981) were juveniles, D. Davies (pers. comm. 1982) suggested that the only likely spawning areas for this species in streams crossed by the North Canol Road occurred in Tay Creek and at the first crossing of the South Macmillan River.

upstream of the Dewhurst Creek crossing (William Stephen, Environmental Coordinator, Pan Ocean Oil Ltd., pers. comm., February 1982).

Northern pike and burbot were each captured in three of the streams sampled by Davies and Shepard (1981), while slimy sculpins were collected from 12 streams. No fish were captured or observed in 15 of the 37 streams at road crossing sites.

In addition to the study conducted by Davies and Shepard (1981), DINA funded a survey and assessment of the potential of numerous streams crossed by the North Canol Road for juvenile chinook salmon overwintering and egg incubation. During this study, which was conducted in February and March 1982, 10 stream crossings were surveyed. Water was found in only four of the 10 creeks, Marjorie Ck., Riddell Ck., Blue Ck. and Pup Ck. No fish were captured during the study. Due to the general lack of water and fish in creeks surveyed, the final report included a recommendation to carry out road construction during winter.

OBJECTIVES

In order to fulfill remaining information requirements for optimum scheduling of road construction, the Department of Indian and Northern Affairs has requested proposals to conduct a study that would meet the following objectives:

1) Determination of the extent of spawning beds of Arctic grayling, chinook salmon and any other important species that may suffer significant adverse effects of construction and identification of these effects.
2) Examination of the timing of migration, spawning and fry emergence, and the identification of construction "windows" for each stream where construction could have adverse impacts.
3) Compilation of a timetable for each stream, showing dates and times of allowable construction with respect to critical periods in fish life cycles.

Following is LGL's proposal to conduct a spring and fall (actually, mid- to late summer) fish resource survey of streams crossed by the North Canol Road in order to fulfill the above objectives.

APPROACH

General

Our approach to conducting the proposed study has been based on the Terms-of-Reference, a review of the report by Davies and Shepard (1981), and discussions with D. Davies and V. Hume. The 1981 study was conducted between mid-June and mid-August. Because Arctic grayling migration and spawning, and emergence of chinook salmon and grayling young-of-the-year has most probably been completed by mid-June, Davies and Shepard (1981) likely missed these events. In addition, sufficient sampling was not conducted during the period that chinook salmon migrate and spawn (most probably the month of August) in the Ross River area.

In order to fulfill remaining information requirements concerning timing and extent of sport fish migration, spawning, emergence and rearing, our proposed field program will consist of a spring and summer sampling period. We propose to conduct sampling at road crossing sites on the creeks listed in Table 1, since Arctic grayling and/or chinook salmon already have been identified as occurring in these creeks. Sampling and assessments, as described later, will be conducted within these streams up to a maximum of 0.5 km and 1.0 km upstream and downstream of road crossings, respectively.

Determination of Migration and Spawning Areas

The extent of spawning areas and the timing of spawning of the two major sport fish, chinook salmon and Arctic grayling, will be determined using a variety of techniques. Arctic grayling spawn during spring just as the ice leaves the streams (mid-May to June in the study area) and seem to prefer rocky or gravelly substrates (McPhail and Lindsey 1970; Morrow 1980). No redd is constructed and the eggs are scattered. Some of the eggs may be buried by the spawning activity. Because grayling do not construct redds, LGL personnel have found in previous studies that one of the most feasible methods of determining grayling spawning areas is by finding concentrations of ripe fish. We will also make note of any spawning activities that we may observe in clear and shallow water. Spawning activity and congregations of fish may be obvious in shallow streams, but in deeper waters, swim surveys using wet suits and snorkelling gear may be necessary.

Migrating and spawning fish will be captured using an electroshocker, seine nets, gill nets and by angling. Electroshocking and seining are usually most effective in shallow areas while gill nets are more efficient in deeper waters. Angling may be the only feasible method of fishing deep pools or along cutbanks and should select for larger fish that might not be captured through other means. The maturity status of fish caught will be determined by the relative ease with which sexual products can be expelled from the fish by squeezing, a technique commonly used to check for ripe fish. All fish captured will be identified, counted, measured (fork length), and released. A few fish may be sacrificed to confirm sex and maturity status, if squeezing does not produce milt or eggs. Details of habitats in which fish are either captured or observed will be recorded.

Chinook salmon are summer spawners in the Yukon; it is believed that they commence spawning activities in the study area in either late July (D. Davies, Dept. Renewable Resources, Yukon Government, pers. comm. 1982) or August (D. deGraaf, LGL Ltd., pers. comm. 1982). Eggs deposited during the summer overwinter and hatch the following spring. Following emergence from the gravel, fry may spend up to two years in freshwater rearing areas. Following this two-year stay in freshwater, the fry (smolt) migrate downstream and out to sea. Chinook salmon demonstrate a great variability in spawning times within their range and, in the Yukon River, runs are known to last for several months. It is not known if the runs, upon reaching the Ross and South Macmillan rivers, become more discrete and predictable, temporally. To ensure that we do not miss the start of the chinook salmon run, we will commence sampling, for spawners on July 20. Spawning areas may be positively identified in the summer by locating the large recently constructed redds and by searching these areas for eggs (D. deGraaf, pers. comm. 1982). Observations of actual spawning behaviour or congregations of fish in spawning condition (ripe) will also be used in our determination of spawning areas. Adult salmon will be captured and processed, or observed as described for grayling. We will also search for chinook salmon in poor condition and for salmon carcasses along streams in the vicinity of road crossing sites, since adults of both sexes die after spawning (McPhail and

Lindsey 1970). The presence of these carcasses will indicate that spawning has occurred recently somewhere in the vicinity (probably upstream).

Determination of Timing and Location of Fry Emergence

The incubation period of chinook salmon eggs is dependent on temperature (Alderdice and Velsen 1978). Morrow (1980) concludes that chinook eggs in Alaska hatch in 12 weeks or more. A 12-week incubation period is probably unrealistic for eastern Yukon populations because this would mean that the eggs deposited the previous summer (July-August) would hatch in mid-winter. Scott and Crossman (1973) state that hatching occurs in spring but they make no special reference to incubation times for northern populations. Alderdice and Velsen (1978) found that, although few studies of incubation periods at low temperatures had been conducted, there were indications that the period could be greater than 24 weeks at incubation temperatures of 3°C. Winter temperatures in Yukon rivers might very well be colder than this. After hatching, fry remain in the gravel for 2 or 3 weeks absorbing their yolk sacs (Scott and Crossman 1973). On the basis of the theoretical timing of events described above, it seems likely that chinook fry should be starting to emerge from the gravel at spring break-up.

The timing of salmon fry emergence at a particular site is most accurately assessed by capturing fry as they emerge from a redd, which may be accomplished through use of a fry emergence trap. A large sock-shaped net trap is placed over the entire redd such that emerging fish must swim into it. Such traps have been used successfully to study patterns of salmonid fry emergence (Porter 1973). We plan to set emergence traps over any salmon redds that we locate upstream or downstream of road crossings. However, emergence traps are only useful if one knows the exact location of redds. During the proposed spring sampling period, locating redds made in the previous summer may be very difficult (spring flows may have caused gravel to cover redds and/or periphyton already may have colonized gravel over redds); consequently, LGL proposes to also sample for emerging chinook fry with small-mesh drift nets that will be set overnight at a variety of stations near each road crossing assessed. Drift nets sample a greater area of the stream and do not have to be placed directly over a redd. Use of drift nets in this manner means that exact spawning sites are not pinpointed; however, it will be easier to sample for salmon fry and, if any are captured, to deduce that spawning occurred somewhere upstream. If spawning occurred in streams somewhere upstream of where drift nets were set, the probability is high that spawning may occur near the road crossing, assuming that habitat (substrate, water depth, etc.) at the crossing was suitable.

There is considerably more knowledge on the timing of hatching of Arctic grayling. Spawning runs are not as protracted temporally, and reported incubation periods vary in length from 11-21 days (Morrow 1980). Grayling fry are free-swimming upon hatching and spend no time living within the gravel substrate. We propose to determine grayling hatching dates and locations on the basis of drift net catches. Emergence traps will not be used because it is very difficult to locate exact spawning areas used by grayling.

If fry emerging from salmon redds are not captured with emergence traps, or if very early-stage fry of salmon and grayling are not captured with drift nets, we propose to determine the timing of emergence for the two species on the basis of back-dating age (based on length and developmental stage) of larger fry captured later in the season with other sampling apparatus. That is, post-larvae and fry of both species will be measured for fork length (to the nearest mm) throughout the study. Length-vs-time curves from emergence to the end of the study (tentatively estimated as late August) will be calculated for those streams where emergence was documented. These lines will be used to estimate times of emergence of fry captured in streams where actual emergence was not observed, but where late-stage fry were captured. Information on early developmental rates of both species will be obtained from the literature to aid in these calculations (e.g., Schluchter and Lichatowich 1977). On the basis of this information, it also will be possible to back-estimate timing of spawning, if it were not possible to determine the timing of this event for both species on the basis of capture of ripe fish or direct observations of spawning. These back-dated estimates of the timing of spawning, hatching and emergence may be important in the determination of sensitive periods in the life histories of the two species.

The relative numbers of each fry species caught at each crossing assessed will be mapped, and the total numbers of fry captured will be used in our qualitative rating (nil, low, medium, high) of the importance of the stream for emerging fry. Evidence of emergence of either species at a particular stream site will also be considered as evidence of spawning in that area, even if spawning fish or eggs were never found in the area.

Determination of Nursery (Rearing) Areas

Following the period of fry emergence during the spring sampling period, plus during the summer sampling period, we propose to meet the objective of locating nursery/rearing areas by electroshocking, seining and drift netting for fry. The relative abundances of fry caught in each area will be assessed and mapped. On the basis of numbers of fry captured we will rate the importance of the stream as a nursery area. The ratings will be qualitative assignments of nil, low, medium or high. Detailed ranking of streams is beyond the scope of a one-year study. (Detailed ranking would require measures of yearly variation in fry use of the areas.) Due to the possibility, or probability, of yearly variation in fry abundances, we also propose to include potential rearing/nursery areas in a separate rating assessment. Potential areas will be considered those that resemble known rearing areas elsewhere in the study area or those described in the literature.

Water Temperature Monitoring

Spawning time of grayling and incubation times of both grayling and chinook salmon are affected by water temperatures (Scott and Crossman 1973; Alderdice and Velsen 1978; Morrow 1980). For this reason, we propose to monitor water temperatures in the study streams with max-min thermometers. This information could be useful in estimating the critical periods of spawning, hatching and emergence. These periods are not likely to be fixed dates from year-to-year, but will vary with spring water temperatures. Data collected on the influence of temperature on the timing of these events in different streams within one season will be useful in estimating yearly differences in the timing of these events in a particular stream. This information could be critical to the establishment of construction "windows" that would not interfere with critical periods in fish life cycles. For example, construction workers, or on-site biologists, could monitor water temperatures in streams crossed by the road in order to determine when a particular life history event was to occur.

Water temperature will also be important in determining estimates of spawning, hatching and/or emergence dates obtained by back-dating fish growth data. Fish growth rates are often temperature dependent; therefore, back-dating must take this parameter into account.

Benthic Invertebrate Sampling

Benthic invertebrates are important components of the diet of both chinook salmon and Arctic grayling. For this reason, ratings of salmon and grayling nursery areas will include a qualitative assessment of the abundances of suitable foods in the nursery area. Invertebrates will be collected through use of a Surber sampler at one site upstream and one site downstream of each road crossing assessed. Samples will be taken in areas that are known to be fish rearing areas or that have potential for rearing young fish. All samples will be collected in riffle areas from July 20-August 20. The samples will be preserved in whirl-paks and transported back to camp for qualitative analysis. Invertebrates will be identified to broad taxa (primarily Order) and the relative volume and abundance of macroinvertebrate taxa will be determined subjectively. Samples will be saved should anyone be interested in analyzing them quantitatively at a later date.

Fish Habitat Information

Davies and Shepard (1981) assessed fisheries potential along the North Canol Road using the methodology described by Chamberlain and Humphries (1977). We will review the unpublished data collected by Davies and Shepard (Point Sample and Reach Tally data cards) and will collect any additional habitat information that is required to fully assess the potential of the waterways crossed by the North Canol Road. This assessment will be based on the same data collection system developed by Chamberlain and Humphries (1977). Important considerations in this analysis will be the substrate types of banks and streambeds and the flow regime of the stream.

This information will be used in conjunction with the hard evidence collected on spawning, emergence and rearing to map and rate known and potential sport fish use of the area.

Sediment deposition sites at road crossings studied will also be mapped and will serve as a basis for comparison with sediment deposition sites that may be determined immediately following construction activities. This procedure will directly monitor the effects of construction activities on downstream siltation, a parameter that affects overall quality of fish spawning and rearing habitat.

Identification of Potential Effects of Construction and Establishment of Construction "Windows"

On the basis of field survey results conducted in 1981 and 1982 (including the proposed study) and information in the literature on known or suspected effects of road construction (or similar activities) on fish habitat, we will identify, discuss and assess the potential impacts of proposed construction activities on chinook salmon and Arctic grayling (and other species in the study area, to a minor extent) habitat and life functions at stream crossings along the North Canol Road. Determination of the timing and extent of spawning, fry emergence and rearing in streams along the road will allow us to compile a timetable for each stream studied showing periods of allowable construction with respect to critical periods in the life cycles of Arctic grayling and chinook salmon. This timetable will include precise dates where possible, and our best estimates of dates when it is not possible for us to clearly define the timing of specific life history events in particular streams. The timetable will include our subjective rating of spawning, emergence and rearing (and overwintering on the basis of the work conducted in February-March 1982) in each stream studied--rating categories will be nil, low, medium and high. Only data pertinent to the compilation of a "Construction Window Timetable" will be analysed.

Schedule of Activities

Field activities will commence with break-up. Following contract award, LGL personnel will contact either Highways Department personnel or the

Government Conservation Officer at Ross River in order to have an individual notify us when ice on streams in the study area begins to break. As soon as we are notified, a two-man crew will fly to Whitehorse and meet with Dan Davies to obtain unpublished stream habitat information. A truck and tent trailer will then be rented in Whitehorse and driven to the study area. The first field trip will last about one month and will involve sampling migrating and spawning Arctic grayling, emerging Arctic grayling and chinook salmon, and early life-stage post-larvae in nursery areas.

To ensure that we are at the study area by the time chinook salmon commence their spawning run, we recommend that the second field trip commence July 20. If the salmon are not running by this date, the crew will capture salmon and grayling fry, assess their growth rates, and determine locations and extent of nursery areas. Invertebrate sampling and sediment deposition mapping could also be conducted late in July if the chinook run does not occur by the time we arrive in the field. When the chinook run begins, the spawning areas will be determined. The summer field season should take approximately one month to complete.

Details of LGL's proposed schedule of activities appear in Table 2.

Table 2. Tentative Schedule of Activities for the Spring and Fall Fish Resource Survey along the North Canol Road.

Task	Tentative Dates (1982)*
Preparation for field trips	May 12-14; July 18,19
Meet with Yukon Government fisheries biologist in Whitehorse	May 15
Sample for migrating and spawning Arctic grayling, emerging Arctic grayling and chinook salmon, and early-stage post-larvae in nursery areas	May 16-June 15
Sampling for migrating and spawning chinook salmon, late-stage grayling and chinook salmon young-of-the-year, benthic invertebrates, and stream sediment deposition.	July 20-August 20
Data analysis, definition and identification of construction "windows" in relation to critical periods in fish life cycles, report preparation	August 21-September 30
Progress report submission	June 30; September 15
Draft report submission	September 30
Final report submission	October 31

*Dates are dependent on timing of ice break-up plus timing of Arctic grayling and chinook salmon runs.

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PROJECT TEAM

Dirk deGraaf, fisheries and aquatic biologist, will be the Project Biologist in charge of the field sampling program. He will also participate in data analysis and report writing together with John Kristensen. Mr. deGraaf, an employee of LGL Ltd. (and affiliate) since 1979, has worked with many salmonid species, including Arctic grayling, chinook salmon, chum salmon and Atlantic salmon. His experience with Arctic grayling and chinook salmon pertains primarily to studies of these two species in relation to proposed pipeline corridors in the Yukon. Prior to joining LGL Ltd., he conducted surveys of spawning and rearing habitat of both Arctic grayling and chinook salmon in numerous streams and rivers in the Yukon, and is familiar with a variety of sampling techniques (seine and gill nets, electroshockers, drift nets) associated with such surveys. Mr. deGraaf's working knowledge of Arctic grayling and chinook salmon in the Yukon will be an asset to the proposed study.

Ian Forster, fisheries technician, will assist Dirk deGraaf in the field. In 1981, he participated in river and stream studies pertaining to emerging chinook salmon fry in the Prince George area. Sampling for young-of-the-year salmon was conducted through use of beach seines, electroshockers, inclined plane trap, fish fence and redd-nets. Mr. Forster has also grit-marked chinook salmon fry and maintained them in holding pens. In addition, he has censused a variety of fish species in streams and rivers along the west coast of B.C.

John Kristensen, Edmonton Regional Director, will supervise the proposed study, participate in data analysis and report preparation, and will maintain liaison between the client and LGL Ltd. He has conducted fisheries studies for the last seven years in the N.W.T., southern Yukon, Alaska, British Columbia and Alberta, concerning fish migration, spawning and rearing. He has participated in numerous projects that have involved the assessment of spawning and rearing habitat of numerous salmonids, including Arctic grayling. Mr. Kristensen has authored several reports concerning salmonid habitat assessment, and has designed and supervised numerous other fisheries and aquatic projects.

Peter Craig, senior aquatic biologist, will review the final report. He has designed, conducted and supervised many fisheries studies in northern Canada and Alaska, numerous of which have been conducted in the Yukon Territory. Dr. Craig conducted a very similar study to that proposed, which involved surveying many stream crossings along the Shakwak Highway in the Yukon Territory and northern B.C. His familiarity with the assessment of spawning and rearing habitat of numerous salmonid species (particularly Arctic grayling), together with his experience in report writing, will ensure that the final report is sound from a scientific perspective.

Detailed resumes are appended.

RELEVANT PROJECT EXPERIENCE

LGL has conducted numerous projects that have involved the identification and assessment of fish spawning and rearing habitat, including that of Arctic grayling and several species of salmon. Below are listed fisheries projects conducted by LGL Ltd. that are most relevant to that proposed for streams along the North Canol Road.

Stream Salmonid Studies Associated with Road or Pipeline Crossings

On behalf of the Canadian Department of Public Works and the U.S. Department of Transportation, LGL carried out studies in 1978 to determine potential impacts to fish resulting from a proposed reconstruction of the Shakwak Highway in the Yukon and northwestern B.C. and to identify preferred seasons for road construction activity near streams. Sampling was conducted with seine nets, electroshockers and fish traps to evaluate the use of streams by spring- and fall-spawning fish species, including Arctic grayling and chinook salmon. Peter Craig conducted this study.

In 1979 and 1980, studies were conducted on behalf of the Northwest Alaskan Pipeline Company on several hundred individual streams along the proposed Northwest Alaskan gas pipeline route through Alaska. A stream catalogue was prepared along with an assessment of the fish spring- and fall-spawning habitat. Peter Craig participated in this study.

Spawning habitat of both spring and fall spawners (including Arctic grayling) was assessed in 12 rivers in the Grande Prairie area as part of an impact study conducted in 1980 by Peace Pipe Line Ltd. The relative quality of sport fish habitat was assessed in relation to proposed oil pipeline crossings.

LGL conducted an examination of the aquatic habitats along alternative routes proposed for the Nanaimo Bypass. Assessment was made of the potential effects of each proposal on aquatic habitats, and recommendations were presented on timing and mitigative measures for construction and operation of the highway in its final location. Peter Craig conducted this study.

Salmonid Habitat Studies in Streams and Rivers

As part of a hydroelectric development impact study, LGL conducted intensive surveys of Arctic grayling and Dolly Varden spawning and rearing habitat in the upper Liard River drainage. Fish were collected through a variety of techniques and habitat was assessed on the basis of the Point Sample and Reach Tally methods developed by the B.C. Government. Both Peter Craig and John Kristensen participated in this project.

Studies were conducted by LGL in 1980 and 1981 on behalf of Newfoundland and Labrador Hydro to describe the potential impacts on fish of a new powerhouse on Dry Pond Brook, Newfoundland. Atlantic salmon spawning habitat was assessed through redd censusing and the capture of young-of-the-year salmon. Dirk deGraaf was responsible for this project.

Arctic grayling habitat was assessed in the Wind River drainage, Yukon, as part of an environmental evaluation of a coal mine and thermal power plant.

On behalf of the Alberta Oil Sands Environmental Research Program, LGL assessed habitat of both spring and fall spawners (including Arctic grayling) in numerous streams within the Alberta Oil Sands area. Fish were captured with seine nets and electroshockers. John Kristensen participated in this project.

On behalf of Esso Minerals Canada, LGL assessed the habitat of fall-spawning salmonids in relation to the identification of potential impacts of mineral extraction activities on aquatic habitats. John Kristensen conducted this study.

Spawning and rearing habitat of several salmonids was assessed by LGL in Glacier National Park in relation to rail grade improvement; in streams of the Spray Lakes Watershed, Alberta in relation to fisheries enhancement studies; and in St. John's in relation to the development of habitat protection guidelines. Dirk deGraaf participated in the St. John's study and John Kristensen participated in the Spray Lakes Watershed study.

In 1982, LGL will be conducting two additional studies that will involve assessing Arctic grayling spawning and rearing habitat. Studies will be conducted west of Edmonton on behalf of Chevron Standard Ltd. and in the Southern Keewatin District, N.W.T. on behalf of a gold mining developer. Both studies will involve capturing grayling through a variety of techniques. John Kristensen will participate in both studies.

TIME, COST AND QUALITY CONTROL

A major factor in the success of LGL Ltd. has been its strength in business and logistics management. Accounting procedures are characterized by an established system of internal controls. Financial reports are provided to project- and corporate-level management personnel each month, which allows for effective monitoring of planned versus actual expenditures on specific projects. Regular technical reports detail technical progress in terms of percent completion and describe any problems which have been encountered. Staff meetings are held as required to solve problems and ensure timely project completion, both on schedule and within budget. Using the management approach abstracted above, LGL has successfully completed over 250 research projects ranging in individual funding from less than $10,000 to over $1 million.

The project team of Dirk deGraaf, Ian Forster, John Kristensen and Peter Craig has been selected to ensure the following:

1) That field personnel (Dirk deGraaf and Ian Forster) are familiar with the subject matter (Arctic grayling and chinook salmon) and working conditions in the Yukon Territory,
2) That the Project Biologist (Dirk deGraaf) has previously been responsible for carrying out similar projects, including supervision of other personnel,
3) That report writers (Dirk deGraaf and John Kristensen) have had ample writing experience, and
4) That the final report is reviewed from the perspective of overall quality by one of LGL's senior aquatic biologists (Peter Craig), who is familiar with the subject matter. Review of the final report by a fisheries biologist not intimately involved with the project will ensure that the identification of appropriate construction windows has been based on sound biological information.

BUDGET*

Personnel

Field (including preparation and travel to and from study area)

D. deGraaf	60 days @ $295/day	$17,700.
I. Forster	60 days @ $150/day	9,000.
Technician	5 days @ $224/day	1,120.

Office

D. deGraaf	20 days @ $295/day ?	5,900.
J. Kristensen	12 days @ $385/day	4,620.
P. Craig	2 days @ $385/day	770.
Secretary	3 days @ $182/day	546.
	Personnel Subtotal	$39,656.

Disbursements

Air travel: 4 Edmonton/Whitehorse R.T. @ $450.	$ 1,800.
Freight	1,400.
Truck and tent trailer rental, and gas	4,200.
Equipment rental: 60 days @ $15/day	900.
Food (in the field): 120 man-days @ $20.	2,400.
Overnight accommodation in Whitehorse: 4 nights @ $35.	140.
Expendables	500.
Drafting: 40 h @ $20/h	800.
Communications	350.
Miscellaneous office	500.
Disbursements Subtotal	$12,990.
TOTAL BUDGET	$52,646.

TENDER OPENING COMMITTEE
THE COMMITTEE CERTIFIES THAT THIS TENDER WAS RECEIVED BEFORE CLOSING TIME AND OFFICIALLY OPENED IN ACCORDANCE WITH GOVERNMENT REGULATIONS.
CHAIRMAN
SECRETARY
WITNESS

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*Budget has been calculated excluding any contingency costs.

RESUMES

DIRK ALEXANDER deGRAAF

Fisheries and Aquatic Biologist

EDUCATION

1972	B.Sc. (Honours) Zoology, University of Manitoba.
1975	M.Sc., University of Calgary, Thesis topic: The life history of pond smelt in a small lake in the northern Yukon Territory.

PROFESSIONAL EXPERIENCE

1979 - present	Fisheries and Aquatic Biologist, LGL Ltd. Project biologist for: - Prepared guidelines for fish habitat protection in urban streams in Newfoundland. - Lower Churchill Development Stream Monitoring Study. - Impact assessment and baseline studies for the hydroelectric development of Dry Pond Brook, Nfld. - Fishery investigations and habitat improvement recommendations for several watersheds within St. John's, Nfld. - Environmental assessment of four bridges along the Trans-Labrador Highway. - Compiled feeding information and prepared final report for northern cod and turbot study as part of the 1979 OLABS project.
1977 - 1979	Fisheries Biologist, Beak Consultants, (Calgary). - Field leader for freshwater fisheries studies within pipeline corridors in Alberta and the Yukon, including collection of benthic invertebrates and measurement of water quality parameters. - Studies of impacts of highway development on aquatic systems in southwest Alberta.
1976 - 1977	Principal of Symbiotech Ltd. and Manager of Aquatic biology section. Duties involved fish, benthic invertebrate and agriculture studies and corporate administration.

DIRK ALEXANDER deGRAAF

Fisheries and Aquatic Biologist

PROFESSIONAL EXPERIENCE (Cont'd)

1975 - 1976	Fisheries biologist with Aquatic Environments Ltd. (Calgary). Duties included project planning, conducting field studies, report preparation and recruitment and co-ordination of personnel. Projects included fisheries studies in the Mackenzie Delta, Beaufort Sea, Alberta, British Columbia, including studies of gas pipeline corridors before and after construction.
1973 - 1974	Fisheries and Aquatic Biologist with Northern Engineering Services Ltd., Calgary. Duties involved planning and conducting field studies, analysis of data and final report preparation. The studies involved surveying fish and benthic invertebrate populations and measuring water quality in streams in the Yukon and Mackenzie District which would be crossed by the proposed Mackenzie Valley Pipeline.
1972 - 1973	Aquatic biologist, Williams Brothers (Canada) Ltd. Responsible for planning and supervising field studies and preparing the final report on the effects of erosion along cutlines upon invertebrates in nearby streams.

REPORTS AND PUBLICATIONS

Author or co-author of numerous fisheries and impact-related reports.

DIRK ALEXANDER deGRAAF

REPORTS AND PUBLICATIONS

McCart, P. and D. deGraaf. 1973. The effect of seismic activity on the benthic invertebrate populations of several small streams near Norman Wells, N.W.T. Arctic Gas Biological Report Series Volume 15.

deGraaf, D.A. 1974. The life history of pond smelt (*Hypomesus olidus*) in a small lake in the northern Yukon Territory. Arctic Gas Biological Report Series Volume 17. 89 p.

Northern Engineering Services Co. Ltd. and Aquatic Environments Ltd. 1975. An intensive survey of the aquatic resources of the Donnelly River system and Chick Lake, Chick Lake Monitoring Studies Volume I. Prepared for Canadian Arctic Gas Study Limited.

Symbiotech Ltd. 1976. Baseline aquatic surveys of the Camsell River, N.W.T. related to the potential impact of mine effluent. Prepared for North Rim Mines Ltd.

deGraaf, D.A. and K. Machniak. 1977. Fisheries investigations along the proposed Cross-Delta Pipeline Route. Arctic Gas Biological Report Series Volume 39, prepared by Aquatic Environments Ltd. 169 p.

Foothills Pipe Lines (Yukon) Ltd. 1977. Fisheries investigations along the Klondike Highway Segment of the Prospective Dempster lateral pipeline route, prepared by Beak Consultants Ltd.

Foothills Pipe Lines (South Yukon) Ltd. 1978. The results of fisheries investigations conducted in water courses crossed by the proposed Alaska Highway Pipe Line during 1977, prepared by Beak Consultants Ltd.

deGraaf, D.A. 1979. Aquatic monitoring of selected streams with regard to potential disturbance resulting from the proposed Lower Churchill Development Transmission Lines. Baseline Studies 1979. Unpubl. Rept. by ABS Ltd. for LCDC, St. John's. 102 p.

Foothills Pipe Lines (Yukon) Ltd. 1979. Fisheries investigations along the proposed Dempster lateral pipeline route, 1978, prepared by Beak Consultants Ltd.

Foothills Pipe Lines (Yukon) Ltd. 1979. A winter survey of water courses crossed by the proposed Dempster lateral pipeline route between Taglu and the Klondike River, prepared by Beak Consultants Ltd.

REPORTS AND PUBLICATIONS (Cont'd)

Foothills Pipe Lines (Yukon) Ltd. 1979. Fishery investigations along the Dawson Trail alternative alignment of the proposed Dempster lateral pipeline route, prepared by Beak Consultants Ltd.

Northland Associates Ltd. and Atlantic Biological Services Ltd. 1979. Proposed Dry Pond Brook hydroelectric development. Environmental preview report. Unpubl. Rept. for Newfoundland and Labrador Hydro, St. John's. 153 p.

deGraaf, D.A. 1980. Trans-Labrador highway bridges. Environmental assessment. Unpubl. Rept. by Atlantic Biological Services Ltd., St. John's. 42 p.

deGraaf, D.A., G.R. Chaput, M.R. Sandeman, and R.A. Buchanan. 1980. Offshore Labrador Biological Studies: Cod and Turbot Feeding Study. The food habits of cod (*Gadus morhua*) and turbot (*Rheinharditus hippoglossoides*) along the Labrador Coast, summer 1979. Unpubl. Rept. by Atlantic Biological Services Ltd. for Total Eastcan Explorations Ltd.

deGraaf, D.A. 1981. Aspects of the diet of cod (*Gadus morhua*) in inshore Labrador waters during Summer, 1979. Paper presented at the 1980 Workshop on Research in the Labrador Coastal and Offshore Region. Goose Bay, Labrador, September 4-6, 1980. (in press).

deGraaf, D.A. 1981. First Canadian record of Bering Cisco (*Coregonus laurettae*) from the Yukon River at Dawson, Yukon Territory. Can. Field Nat. 95(__):__-__. (in press).

deGraaf, D.A., B.K. Boles and J.J. Lovisek. 1981. Two-lined salamander (*Eurycea bislineata*) in Labrador. Range Extension. Submitted to Can. Field. Nat. (in prep.).

deGraaf, D.A. 1981. Fisheries investigations in the vicinity of the proposed Dry Pond Brook hydroelectric development. Unpubl. Rept. by LGL Ltd. for Newfoundland and Labrador Hydro, St. John's. 111 p.

IAN FORSTER

Fisheries Technician

EDUCATION

1980	B.Sc. Zoology, University of British Columbia.

PROFESSIONAL EXPERIENCE

1981	Assisted Envirocon biologists with river and stream studies pertaining to emerging chinook salmon fry in the Prince George area -- sites at Slim Creek 100 km east of Prince George; Nechako River at Prince George; and Nechako R. between Fort Fraser and Vanderhoof. Work experience includes operation of incline plane traps; grit-marking chinook salmon fry; identification of local species; quantitative beach seining and electroshocking; maintenance and operation of fish-fence on Nechako R.; measuring and scaling of salmon fry for fry quality assessment; installation and maintenance of redd-nets. Other duties included maintenance of fry in pens; maintenance of camps (trailers and tents) and boats; extensive use of pontoon boats with jets; preparation of data sheets; run-off estimation using staff gauges and electronic flow meters. Analysed cod and ground-fish catch data for B.C. Provincial Government at Pacific Biological Station.
1979 and 1980	Participated in experiments, sampling, sorting, identification and counting of zooplankton at the University of British Columbia Institute of Animal Resource Ecology.
1977	Stationed at a West Coast Biological Research Camp which was involved in undertaking a variety of experiments. Participated in operating a weather station, censusing rivers and streams using seining techniques and electroshock equipment, operating fish gates, identifying and sorting, collecting benthic material in river beds, as well as other data gathering activities.

JOHN KRISTENSEN

Fisheries and Wildlife Biologist; Regional Director

EDUCATION

1973	B.Sc. (Honours Zoology), University of Alberta.
1973 - 1975	Graduate Studies, Zoology, University of Alberta.

PROFESSIONAL EXPERIENCE

1981-present	Member of LGL Board of Directors. Administrative, supervisory and field research responsibilities including involvement with all Edmonton office projects. Designed, supervised and/or participated in many projects including the following: fisheries and limnological inventory studies; fisheries enhancement studies; and studies to determine impacts of various developments (e.g., pipelines, urbanization, water extraction, water control structures including hydroelectric dams, mining, gas processing) on lower trophic levels, fish, birds and mammals.
1980	Appointed Regional Manager, LGL, Edmonton office. Participated in Prairie Provinces Water Board Ecological Considerations Study which included the study of critical wildlife and fish habitat in five major Alberta river basins. Conducted and supervised study of fish behaviour and movement in the vicinity of two water control structures in the Peace-Athabasca Delta. This study included determining the functional engineering design for suitable fish passage facilities. Participated in field study to assess the impacts of pipeline construction on the water quality and aquatic invertebrates of the Fort Nelson River in northeastern B.C. Conducted a raptor and colonially nesting bird survey in the Cold Lake area, Alberta. Conducted aquatic habitat and fisheries research in northern B.C. to determine potential effects of hydroelectric development on fish resources in the Liard River system.
1979	Conducted and supervised study to document the aquatic fauna and flora of a mountain stream and lake in north-central B.C. Fish, drift and benthic invertebrates, zooplankton, phytoplankton, periphyton, and water quality and sediment parameters were studied. Participated in aquatic habitat mapping study of several streams in the Alberta Oil Sands Environmental Research Program study area. Involved with a simulation modelling workshop on the environmental effects of Alberta oil sands development. Participated in field

JOHN KRISTENSEN

Fisheries and Wildlife Biologist; Regional Director

PROFESSIONAL EXPERIENCE (Cont'd)

1979 (cont'd)	studies to document use of a salt-water lagoon in the Prudhoe Bay, Alaska area by fish and invertebrates, and to document use of the early summer ice edge at Pond Inlet, N.W.T. by marine phytoplankton, invertebrates, fish, birds and mammals.
1978	Conducted research to determine nesting success of western grebes at Cold Lake, Alberta, and conducted waterfowl, raptor, colonial bird, upland game bird and ungulate aerial and ground surveys in the same area. Conducted and supervised research to assess a commercial walleye fishery and to identify spawning locations and determine spawning success of walleye in the Peace-Athabasca Delta, Alberta.
1977	Conducted and supervised research to determine onset and duration of spring movement, spawning success, and meristic characters of goldeye in the Peace-Athabasca Delta.
1976	Conducted and supervised research on movement of goldeye and other fish species past weirs in the Peace-Athabasca Delta and on the timing and location of goldeye migration from the Delta.
1975	Joined LGL Limited. Conducted a literature review of potential impacts of a major roadway on birds and assisted with the analysis of coastal Beaufort Sea bird data. Conducted research on the spawning success and life history of goldeye in the Peace-Athabasca Delta.
1973 - 1975	Conducted research on the aggressive interaction among female blue grouse on Vancouver Island, B.C. Teaching assistant, undergraduate biology courses. Courses included the following: Natural history of Alberta vertebrates, Mammalogy, Wildlife management.
1971 - 1973	Field research assistant, University of Alberta. Participated in the study of population dynamics of blue grouse on Vancouver Island. Specialized in distraction display behaviour of females.
1970	Field assistant, University of Alberta, on paleozoological studies of Cretaceous mammals and dinosaurs near and in Dinosaur Provincial Park, Alberta.

JOHN KRISTENSEN

PUBLICATIONS, REPORTS AND ARTICLES

LGL Limited. 1975. Potential impact of Sarcee Trail (Weasel Head Route A) on avian fauna. Prepared for Reid, Crowther and Partners Ltd. 12 p.

Kristensen, J., B.S. Ott and A.D. Sekerak. 1976. Walleye and goldeye fisheries investigations in the Peace-Athabasca Delta--1975. Alberta Oil Sands Environmental Research Program Report No. 2, Project AF 4.1.1. 103 p.

Kristensen, J. 1977. The goldeye - a local anomaly. The Edmonton Naturalist 5(2):28-30.

Zwickel, F.C., J.A. Redfield and J. Kristensen. 1977. Demography, behaviour, and genetics of a colonizing population of blue grouse. Canadian Journal of Zoology 55(12):1948-1957.

Kristensen, J. and S.A. Summers. 1978. Fish populations in the Peace-Athabasca Delta and the effects of water control structures on fish movements. Canadian Fisheries and Marine Service Manuscript Report No. 1465. 62 p.

Kristensen, J. 1979. Walleye studies in the Peace-Athabasca Delta, 1978. Prepared by LGL Ltd. for Fisheries Subcommittee, Peace-Athabasca Delta Monitoring Committee. 54 p.

Kristensen, J. and W.R. Nordstrom. 1979. Western grebe colony, Cold Lake. Prepared by LGL Ltd. and Prov. Parks Div., Alta. Recreation, Parks and Wildl. for Alta. Recreation, Parks and Wildl. and Esso Resources Canada Ltd. 47 p.

Kristensen, J. and M.G. Foy. 1980. First record of the round whitefish in Alberta. Canadian Field-Naturalist 94(2):180-182.

Kristensen, J. 1980. Large flathead chub (*Platygobio gracilis*) from the Peace-Athabasca Delta, Alberta, including a Canadian record. Canadian Field-Naturalist 94(3):342.

Kristensen, J. 1980. Kutcho Creek project, stage II: environmental baseline studies, fall 1979; surface hydrology, water quality, and aquatic flora and fauna. Prepared by LGL Ltd. for Esso Minerals Canada. 191 p.

Kristensen, J. 1981. Great blue heron (*Ardea herodias*) colony in the Peace-Athabasca Delta, Alberta. Canadian Field-Naturalist 95(1): 95-96.

JOHN KRISTENSEN

PUBLICATIONS, REPORTS AND ARTICLES (Cont'd)

Kristensen, J. and S.A. Summers. 1981. Fish populations in the Peace-Athabasca Delta and the effects of water control structures on fish movements: Data. Canadian Fisheries and Marine Service Data Report No. 61. 216 p.

Andrew, J.H., J.A. Taylor, A.D. Sekerak and J. Kristensen. 1981. Late winter fisheries studies in the Spray Lakes Reservoir watershed, 1981. Prepared by LGL Ltd. for Alberta Fish and Wildlife Division. 94 p.

Taylor, J.A., J.H. Andrew, J. Kristensen and A.D. Sekerak. 1981. Evaluation of the fisheries potential of the Spray Lakes Reservoir watershed. Prepared by LGL Ltd. for Alberta Fish and Wildlife Division. 66 p.

Kristensen, J. 1981. Investigations of goldeye and other fish species in the Wood Buffalo National Park section of the Peace-Athabasca Delta, 1977. Canadian Manuscript Report, Fisheries and Aquatic Sciences, No. 1560. 64 p.

Kristensen, J. 1981. Fishes of the Peace-Athabasca Delta. Alberta Naturalist 11(2):69-76.

Kristensen, J., J.E. Green and J.A. Taylor. 1982. Potential biological impacts of additional water withdrawals from Ethel Lake, Alberta. Prepared by LGL Ltd. for Water Resources Administration Division, Alberta Environment. 39 p.

Buchwald, V. and J. Kristensen. 1982. Whitemud Creek master drainage plan study, aquatic fauna and habitat-Interim report. Prepared by LGL Ltd. for Hardy Associates (1978) Ltd. 38 p.

PETER C. CRAIG

Senior Aquatic Biologist

EDUCATION

1967	B.A., (Biology), Stanford University, California.
1969	M.A., (Biology), University of California, Santa Barbara.
1973	Ph.D., (Biology), University of California, Santa Barbara..

PROFESSIONAL EXPERIENCE

1977 to date	Senior Aquatic Biologist, LGL Limited, Sidney, British Columbia. Supervisor of aquatic research. Projects include ecological studies of fishes, invertebrates, and water quality in nearshore marine and freshwater habitats in the Beaufort Sea, Alaska.
1973 - 1977	Senior Biologist, Aquatic Environments, Ltd., Calgary, Alberta. Position involved original fisheries research, administration, and consulting in aquatic biology.
1972 - 1973	Fisheries Biologist, Northern Engineering Services, Calgary, Alberta. Conducted ecological studies of arctic aquatic resources, directed field crews, and assessed environmental impact of a proposed gas pipeline.
1970 - 1972	Fisheries Consultant, Alyeska Pipeline Service Company, Bellevue, Washington. Conducted ecological studies of fish and stream invertebrates on Alaska's North Slope and assisted in assessing environmental impact of the Trans Alaska pipeline.
1967 - 1970	Teaching Assistant, University of California, Santa Barbara. Courses included General Biology, Zoology, Botany, and Entomology.

PETER C. CRAIG

Senior Aquatic Biologist

SELECTED PROJECT EXPERIENCE

BLM/OCSEAP. A three year on-going field program which examines ecological processes operating in a lagoon-barrier island ecosystem of the Beaufort Sea, with particular emphasis on the role of fishes during winter and open-water seasons.

Prudhoe Bay Waterflood Project. Examination of potential impacts to arctic fish resources resulting from causeways in nearshore environments. Participation in OCSEAP-sponsored workshop and also invited by the Army Corps of Engineers to participate in a subsequent review of potential problems involving fish passage around nearshore causeways.

ABSORB. Reviewed existing fisheries information pertaining to the entire Alaskan Beaufort Sea coastline and prepared sensitivity rankings for fisheries habitats.

Canadian Beaufort Sea. Prepared annotated bibliography of fish resources along the Canadian Beaufort Sea for ESSO Resources, Canada.

Trans Mountain Tanker Route. Inventory of major fish resources along coast of British Columbia and impact assessment of potential oil spills on fisheries.

B.C. Hydro. Project director of major inventory and impact study of proposed hydroelectric developments in the Liard River drainage.

PETER C. CRAIG

Senior Aquatic Biologist

RESEARCH

Since 1970, research has been conducted in Alaska and northern Canada. This work has involved ecological studies of fish species (e.g., Arctic char, grayling, whitefish, sculpins), invertebrates, and water quality in both freshwater and marine habitats. Fisheries studies include: stream inventories, life histories, toxicity experiments, migrations, temporal and spatial use of streams, lakes and coastal areas. A major research emphasis has been the ecology of salmonids in northern drainages; other investigations have been designed to examine specific industrial problems, e.g., the effects of pipeline construction on streams and fish populations and the effects of offshore development on Beaufort Sea fish and invertebrates. Examples of these studies are listed under Publications and Reports.

Participation in an oceanographic expedition (Stanford University) with research emphasis on the distribution of pelagic coelenterates.

Graduate research involved studies of the ecology and behavior of several species of intertidal invertebrates inhabiting sandy beach (see Publications).

PUBLICATIONS AND REPORTS

Craig, P.C. 1968. The activity pattern and food habits of the limpet, *Acmaea pelta*. Veliger 11 (Supplement): 13-19.

Craig, P.C. 1970. The distribution and behavior of the intertidal sand beetle, *Thinopinus pictus* (Staphylinidae). Ecology 51:1012-1017.

Craig, P.C. 1971. An analysis of the concept of lunar orientation in *Orchestoidea corniculata* (Amphipoda). Animal Behavior 19:368-374.

McCart, P. and P.C. Craig. 1971. A comparision of meristic characteristics of freshwater and anadromous Arctic char, *Salvelinus alpinus*. Journal of the Fisheries Research Board of Canada 28:115-118.

PETER C. CRAIG

Senior Aquatic Biologist

PUBLICATIONS (cont'd)

Craig, P.C. 1973. Orientation of the sand-beach amphipod, *Orchestoidea corniculata.* Animal Behavior 21:699-706.

McCart, P. and P.C. Craig. 1973. Life history of two isolated populations of Arctic char *(Salvelinus alpinus)* in spring-fed tributaries of the Canning River, Alaska. Journal of the Fisheries Research Board of Canada 30:1215-1220.

Craig, P.C. 1973. The behavior and distribution of a sand-beach amphipod, *Orchestoidea corniculata.* Marine Biology 23:101-109.

Craig, P.C. and P. McCart. 1975. Classification of streams in Beaufort Sea drainages between Prudhoe Bay, Alaska and the Mackenzie River, Northwest Territories. Arctic and Alpine Research 7:183-198.

Craig, P.C. and J. Poulin. 1975. Movements and growth of Arctic grayling *(Thymallus arcticus)* and juvenile Arctic char *(Salvelinus alpinus)* in a small arctic stream, Alaska. Journal of the Fisheries Research Board of Canada 32:689-697.

Craig, P.C. and P. McCart. 1976. Fish use of nearshore coastal waters in the western arctic: emphasis on anadromous species. Chapter 26, pages 361-388 *in* Hood and Burrell (editors), Assessment of the arctic marine environment; selected papers. Occas. Publ. No. 4, Institute of Marine Science, University of Alaska, Fairbanks.

Craig, P.C. and J. Wells. 1976. Life history notes for a population of slimy sculpin *(Cottus cognatus)* in an Alaskan arctic stream. Journal of the Fisheries Research Board of Canada 33:1639-1642.

Craig, P.C., F. Withler, and B. Morley. 1977. Effects of methanol on the fertilization of chum salmon *(Oncorhynchus keta)* ova. Environmental Pollution.

Craig, P.C. 1978. Movements of stream-resident and anadromous Arctic char *(Salvelinus alpinus)* in a perennial spring on the Canning River, Alaska.

PETER C. CRAIG

Senior Aquatic Biologist

REPORTS

McCart, P., P.C. Craig, and H. Bain. 1972. Report on fisheries investigations in the Sagavanirktok River and neighboring drainages. Report to Alyeska Pipeline Service Company, Bellevue, Washington. 150 p.

Craig, P.C. and P. McCart. 1974. Fall spawning and overwintering areas of fish populations along routes of a proposed pipeline between Prudhoe Bay and the Mackenzie Delta. Canadian and Alaskan Arctic Gas Study, Biological Report Series 15(3). 36 p.

Ward, D. and P.C. Craig. 1974. Catalog of lakes, streams, and coastal areas in Alaska along routes of the proposed gas pipeline from Prudhoe Bay, Alaska to the Alaskan-Canadian border. Canadian and Alaskan Arctic Gas Study, Biological Report Series 19. 381 p.

Craig, P.C. and G. Mann. 1974. Life history and distribution of the Arctic cisco *(Coregonus autumnalis)* along the Beaufort Sea coastline in Alaska and the Yukon Territory. Canadian and Alaskan Arctic Gas Study, Biological Report Series 20(4). 32 p.

Craig, P.C. and J. Wells. 1975. Fisheries investigations in the Chandalar River region, northeast Alaska. Canadian and Alaskan Arctic Gas Study, Biological Report Series 34(1). 114 p.

Griffiths, W.B., P.C. Craig, G. Walder, and G. Mann. 1975. Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon Territory). Canadian and Alaskan Arctic Gas Study, Biological Report Series 34(2). 171 p.

Tape, B. and P.C. Craig. 1975. Reconnaissance of the Alyeska Pipeline: material source borrow methods and an evaluation of these methods with respect to aquatic habitats. Report to Canadian Arctic Gas Study Limited. 28 p.

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PETER C. CRAIG

Senior Aquatic Biologist

REPORTS (cont'd)

Craig, P.C. 1976. Arctic char in Sadlerochit Springs, Arctic National Wildlife Range. Presented at the 27th Alaska Science Conference, Fairbanks, Alaska, 6 August 1976. Also in Biological Report Series 41(2) of the Canadian and Alaskan Arctic Gas Study. 30 p.

Griffiths, W.B., J. DenBeste, and P.C. Craig. 1977. Fisheries investigations in a coastal region of the Beaufort Sea (Kaktovik Lagoon, Alaska). Canadian and Alaskan Arctic Gas Study, Biological Report Series 40(2). 180 p.

Craig, P.C. 1977. Ecological studies of anadromous and resident populations of Arctic char in the Canning River drainage and adjacent coastal waters, Alaska. Canadian and Alaskan Arctic Gas, Biological Report Series 41(1). 116 p.

Craig, P.C. 1977. Fisheries research in the Shaviovik drainage with emphasis on Arctic char in the Kavik River, Alaska. Canadian and Alaskan Arctic Gas Study, Biological Report Series 41(3). 28 p.

Childers, R. and P.C. Craig. 1977. A model environmental protection program with an assessment of industrial and government surveillance along the Trans Alaska pipeline. Report to Alaskan Arctic Gas Study Company, Anchorage, Alaska. 120 p.

Craig, P.C. and W.B. Griffiths. 1978. Ecology of fishes in Simpson Lagoon, 1977. Section III *in* Beaufort Sea Barrier Island-Lagoon Ecological Process Studies, Annual Report by LGL Limited, Environmental Research Associates, to NOAA-OCSEAP, Boulder, Colorado.

PETER C. CRAIG

Senior Aquatic Biologist

REPORTS (cont'd)

Craig, P. and G. Glova. 1977. Catalogue of streams crossed by the Haines Road/Alaska Highway in British Columbia and the Yukon Territory. Rep. by LGL Ltd. for Shakwak Highway Improvement Project, Public Works Canada and U.S. Federal Highway Administration. 75 p.

Craig, P. and G. Glova. 1978. Winter and summer fisheries surveys for the Shakwak Highway Improvement Project, B.C. and the Yukon Territory. Report for Public Works Canada. 65 p.

Chihuly, M., D. Ward, P. Craig, R. McMilland and R. Morrison. 1980. Spring fisheries survey and provisional list of waterbodies along the Alaskan Gas Pipeline route (Prudhoe Bay to the Yukon Territory) proposed by Northwest Alaskan Pipeline Co. Rep. by LGL Ltd. (Alaska) for Northwest Alaskan Pipeline Co. 211 p.

Craig, P., H. McElderry and K. Wiley. 1980. Fish. p. 113-150 and 344-352. *In*: Vol. 16. In the matter of a pipe line by Trans Mountain Pipe Co. Ltd. for a certificate of public convenience and necessity authorizing the construction and operation of a parallel 762 mm diameter pipeline to accommodate eastward flow of crude oil. Rep. by LGL Ltd. (Sidney) and ESL Environ. Serv. Ltd. for Trans Mountain Pipe Line Co. Ltd. (Vancouver).

Craig, P.C. and W. Griffiths. 1981. Studies of fish and epibenthic invertebrates in coastal waters of the Beaufort Sea. *In*: Environ. Assess. Alaskan Cont. Shelf, Annu. Rep. Prin. Invest., BLM/NOAA, OCSEAP. Boulder, Colo.

Craig, P.C. 1981. Biophysical and social inventory: fish. p. 19-23 and biological inventory maps: Fish. p. 42-579. *In*: Alaska Beaufort Sea coastal sensitivity analysis phase 1. Rep. by LGL Ltd. (Sidney) for ABSORB Alaskan Beaufort Sea Oilspill Response Body (Houston).

Craig, P.C. and L. Haldorson. 1981. Beaufort Sea Barrier island-lagoon ecological process studies: Final report Simpson Lagoon. Part 4. Fish. p. 384-678. Res. Unit 467. *In*: Environ. Assess. Alaskan Cont. Shelf, OCS. Final Rep. Prin. Invest. Vol. 7.

PETER C. CRAIG

Senior Aquatic Biologist

REPORTS (cont'd)

Craig, P.C. and W. Griffiths. 1981. Passage of large fish around a causeway in Prudhoe Bay, Alaska. Arctic 32 (in press).

Craig, P.C. and D. Schmidt. 1982. Fisheries surveys at potential dredging sites at North Slope villages: Wainwright, Point Lay, Atkasook, Nuiqsut and Kaktovik. Rep. by LGL Ltd. (Sidney) for the North Slope Borough.

Craig, P.C., W. Griffiths, L. Haldorson and H. McElderry. 1982. Ecological studies of Arctic cod (*Boreogadus saida*) in Beaufort Sea coastal waters, Alaska. Can. J. Fish. Aquat. Sci. (in press)

Craig, P.C. and K. Bruce. 1982. Fish resources in the Upper Liard River drainage, B.C. *In*: A.D. Sekerak (ed.). Fish resources and proposed hydroelectric development in the Upper Liard River drainage. Rep. by LGL Ltd. (Sidney) for B.C. Hydro and Power Auth.

Skvorc, P. and P. Craig. 1982. Review of fisheries information for the Chukchi Sea. Rep. by LGL Ltd. (Alaska) for BLM/NOAA, OCSEAP Outer Continental Shelf Environmental Assessment Program.

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